

0001-4575(94)00043-3

MARIJUANA AND OTHER DRUG USE AMONG AUTOMOBILE AND MOTORCYCLE DRIVERS TREATED AT A TRAUMA CENTER*

CARL A. SODERSTROM,¹ PATRICIA C. DISCHINGER,² TIMOTHY J. KERNS,² and ANNA L. TRIFILLIS³

¹Department of Surgery, R Adams Cowley Shock Trauma Center, University of Maryland Medical Center, 22 S. Greene St., Baltimore, MD 21201-1595, U.S.A.; ²Charles McC. Mathias National Study Center for Trauma and Emergency Medical Services, University of Maryland School of Medicine, Baltimore, MD, U.S.A.; ³Department of Pathology, University of Maryland School of Medicine, Baltimore, MD, U.S.A.

(Accepted 12 February 1994)

Abstract—Serum from injured automobile and motorcycle drivers treated at a trauma center was tested for δ -9-tetrahydrocannabinol activity to determine precrash marijuana use. From June 1990 to March 1991, samples from approximately 20 automobile drivers per month and all motorcycle drivers were available for testing. Also, toxicology screens were performed for ethyl alcohol, cocaine, and phencyclidine (PCP) among the driver groups. Six (2.7%) of the 225 automobile (AUT) drivers and 34 (32.0%) of the 106 motorcycle (MTC) drivers were THC+ (p < .001). Compared with a prior study, the THC+ rate decreased significantly from 31.8% among AUT drivers (p < .001) but had not changed significantly from the 38.6% rate among MTC drivers. Positive toxicology rates were higher among the 261 MTC drivers compared to the 1,077 AUT drivers tested for ETOH, CO, and PCP, being 47.1% vs 35.2% (p < .001), 5.0% vs 8.0% (p < .08), and 1.5% vs 3.1% (NS), respectively.

Marijuana use prior to injury among patients admitted to the Maryland Institute for Emergency Medical Services Systems. (MIEMSS) Shock Trauma Center was documented in a previous report (Soderstrom et al. 1988). A radioimmunoassay (RIA) for δ -9-tetrahydrocannabinol (THC), the major psychoactive component of marijuana, was performed on the serum of 1,023 trauma victims, including 393 automobile (AUT) and 70 motorcycle (MTC) drivers, between July 1985 and May 1986. The pre-injury marijuana use rates of 31.8% and 38.6% for the automobile and motorcycle drivers, respectively, did not differ significantly from the 32.4% rate for nonvehicular trauma victims.

Tests for metabolites of marijuana can yield positive results days to weeks after cessation of use (Ellis et al. 1985). In contrast, the serum half-life of THC is about one hour (Moeller, Doerr, and Warth 1992); hence, after four hours, serum tests for THC are usually negative (Heustis, Henningfield, and Cone 1992; Moeller et al. 1992; Yeager et al. 1981). A positive result, with a level ≥ 2 ng/ml, suggests recent marijuana use (Heustis et al. 1992). Hence, RIA of THC activity on admission serum allows for evaluation of marijuana use rates proximal to the time of injury. (RIA testing is specific for the δ -9-THC metabolite.)

Large studies of blood testing for THC have involved fatally injured drivers. Of 600 North Carolina drivers killed in single-vehicle crashes, 7.8% were THC positive (lower limit, 3.0 ng/ml) (Mason and McBay 1984). In a Canadian study of 1,169 drivers, 10.9% were THC + (lower limit, 0.2 ng/ml; mean 3.1 ng/ml; median 1.6 ng/ml). A higher THC + rate of 36.8% (lower limit, 0.2 ng/ml; 14.7% \geq 2 ng/ nl) was reported by Williams and colleagues (1985) for male drivers (n = 440) aged 15 to 34 years. These studies did not focus on cyclists. In a Canadian study (Cimbura et al. 1990; Mayhew, Donelson, and Simpson 1987) of 728 automobile and 192 motorcycle

^{*}Presented at the 37th Annual Meeting of the Association for the Advancement of Automotive Medicine, November 4–6, 1993, San Antonio, Texas.

Table 1.	"Past month"	alcohol, cocaine, and marijuana use rates
	from NIDA	National Household Surveys

	1985 (%)	1988 (%)	199 1 (%)
Total population			
United States			
Alcohol	59	53	51
Cocaine	2.9	1.5	0.9
Marijuana	9.4	5.9	4.8
South			
Alcohol	47	45	44
Cocaine	1.4	1.0	0.8
Marijuana	8.0	4.8	3.9
18-34 years of age			
United States			
Alcohol	71	65	63
Cocaine	6.9	3.4	1.9
Marijuana	19.1	12.8	10.0
South			
Alcohol	61	55	57
Cocaine	3.6	2.3	1.6
Marijuana	18.0	10.3	8.9

drivers, the cyclists had a THC + rate over two times higher than automobile drivers, being 22% and 9%, respectively.

Most studies of marijuana use among trauma center patients have utilized urine testing for marijuana metabolites. Positive results have ranged between 24% and 38% (Clark et al. 1991; Kirby, Maull, and Fain 1992; Rivara et al. 1989; Sloan et al. 1989). Serum studies of marijuana use among patients treated in emergency departments or trauma centers are uncommon. Terhune and Fell (1981) tested 497 injured drivers treated in a Rochester, New York, emergency department. The resulting 9.7% positive rate for THC must be considered guite conservative in light of the 29% refusal rate to participate in the study. In 1989, Lindenbaum and colleagues noted that 37% of 169 patients at a Philadelphia trauma center were THC positive. About half were victims of "accidental injury," and the remainder were injured as the result of violent crime.

The 1985, 1988, and 1991 National Household Surveys of Drug Abuse demonstrate a trend toward decreased "past month" use of marijuana, alcohol, and cocaine both nationally and for the "south" region, which includes Maryland (National Institute on Drug Abuse 1988, 1989, 1991). Those trends are reflected in Table 1. Data for those aged 18 to 34 years, the group representing the majority of trauma center patients nationally (Champion et al. 1990), are also presented.

In light of these trends, we (i) reassessed marijuana use among injured automobile and motorcycle drivers treated at our center and (ii) assessed alcohol, cocaine, and phencyclidine (PCP) use.

MATERIALS AND METHODS

Study candidates included all automobile and motorcycle drivers admitted to the Shock Trauma Center from the injury scene from June 1990 through May 1991. During that period, the primary clinical mission of the Center was to serve as the Level I regional trauma center for counties surrounding Baltimore. Hence, the majority of the patients were injured in suburban or rural settings. Most were transported by medical evacuation helicopters. The time from crash impact to arrival at the Center averaged one hour. Drivers were identified by linking data from the Maryland State Trauma Registry and State Police crash report computer tapes.

Leftover serum samples from routine admission diagnostic blood tests were frozen and stored. Samples from approximately 20 randomly selected automobile drivers per month and all motorcycle drivers were assayed for THC activity. Before testing, all patient identifiers were removed. This methodology protected patient confidentiality and obviated the need for patient consent. The testing procedure was the same as that used in our previous study (Soderstrom et al. 1988). (The test kit is manufactured by Research Triangle Institute [Research Triangle Park, NC] for the National Institute on Drug Abuse. Prior to each set of assays, RIA kits with newly prepared radiolabelled specific antiserum are obtained.) THC values $\geq 2 \text{ ng/ml}$ were considered positive for marijuana use. (Such a standard is consistent with that used in prior studies [Mason and McBay 1984; Cimbura et al. 1990; Heustis et al. 1992].)

Alcohol, cocaine, and PCP toxicology test results routinely obtained on admission and stored in a Trauma Patient Toxicology Database were analyzed. Blood alcohol concentrations (BACs) are determined on more than 95% of patients, and more than 80% of patients are tested for the other drugs. To allow for meaningful analysis of drugs with low use rates, the sample size was increased by doubling the study period from 10 to 20 months. This was done by assessing drivers admitted for the five months before and after the marijuana testing study period.

RESULTS

Marijuana

During the marijuana study period, 491 automobile drivers and 117 motorcycle drivers were admitted. More of the cyclists were men (91% versus 64%) and they had a lower mean age (28 versus 34 years) than the automobile drivers. Only 7.5% were injured in the city of Baltimore.

1990-August 1991)				
	Automobile drivers (N = 1077)	Motorcycle drivers (N = 261)	p	
Alcohol 35.2% Mean BAC 160 mg/di		47.1% 141 mg/dl	<.001* <.001†	
Cocaine	5.0%	8.0%	<.08*	
PCP	1.5%	3.1%	NS	

Table 2. Positive toxicology rates of injured automobile and motorcycle drivers treated at Shock Trauma Center (January 1990-August 1991)

*Chi square.

+Student's t-test.

A total of 225 automobile drivers and 106 motorcycle drivers were tested for THC. Since marijuana testing is not done routinely at the Center, marijuana test results could not be linked to other toxicology results or demographic data without violating patient confidentiality.

Six automobile drivers (2.7%) were THC + . In contrast, 34 motorcycle drivers (32.0%) were THC +. The rate of preinjury marijuana use among the cyclists was 12 times higher than among the automobile drivers (p < 0.001, chi-square analysis).

Alcohol and other drugs

Complete toxicology data were available for 1,077 automobile drivers and 261 motorcycle drivers treated at the Center between January 1990 and August 1991 (20 months). The demographic profile for these larger groups of drivers was similar to that from the marijuana study period. Men constituted 65% of the automobile drivers (mean age, 34 years) and 92% of the cyclists (mean age, 28 years). Again, only 7.5% were injured in the city of Baltimore.

Results of analysis for alcohol, cocaine, and PCP among the automobile and motorcycle drivers during the 20-month period are presented in Table 2. For all drugs, the use rate was higher for the cyclists. The mean BAC was significantly higher for the automobile drivers.

DISCUSSION

Marijuana

The current study results document a significant decrease in preinjury marijuana use among automobile drivers compared with the prior study (Soderstrom et al. 1988)—2.7% versus 31.8%; P < .001, (chi-square analysis). In contrast, the 32.0% use rate in the current study among the cyclists is not significantly different from the prior 38.6% rate. In Table

Table 3. Preinjury marijuana and alcohol use among injured automobile and motorcycle driver treated at the Shock Trauma Center: Comparison of two studies

	Test positive results				
	Automobile drivers (%)		Motorcycle drivers (%)		
	1985-1986	1990-1991	1985-1986	1990-1991	
Marijuana Alcohol	31.8 34.6	2.7 35.2	38.6 50.0	32.0 47.1	

3 the marijuana and alcohol results of the two studies are compared.

We cannot explain why the marijuana use rates decreased dramatically among the automobile drivers and not among the cyclists. The dramatic drop in marijuana use among the automobile drivers cannot be explained by age changes between the 1985-1986 and the 1990-1991 groups. As noted, the mean age of the automobile drivers was 34 years in the current study. In the previous study, approximately 60% of automobile drivers were 30 years old or under (Soderstrom et al., 1988). During the interval between the two studies, the age distribution of patients admitted to the Center did not change significantly. Data from the Maryland Alcohol and Drug Abuse Administration's Substance Abuse Management Information System (SAMIS) are worth noting (SAMIS 1992). All certified treatment programs in the state are required to provide admission and discharge data to SAMIS. Mentions of marijuana problems in those records decreased slightly from fiscal year 1988 to 1992 by a factor of 9%. In contrast, mentions of cocaine increased by 54% and alcohol by 23%.

The cyclists' use rates of marijuana in our two studies are comparable to the approximately 40% rate obtained from urine tests of 66 cyclists studied by Rivara and colleagues (1989) at a Seattle trauma center. These results are higher than those obtained in a study of 48 motorcycle and 291 four-wheeledvehicle drivers treated in a Toronto trauma center. Stoduto and associates (1991) noted that 41% of both groups were positive for drugs other than alcohol, with 15% being urine positive for marijuana use. (Marijuana use for each group of drivers was not given.)

Alcohol

The alcohol use rates of 35.2% and 47.1% for the automobile and motorcycle drivers, respectively, in this study are similar to the 34.6% and 50.0% rates from our previous study (Soderstrom et al. 1988). The BAC + rate in both studies is a little lower than the 53.3% rate among another group of 165 cyclists tested at our center (Soderstrom et al. 1993). This study's BAC + rates are also similar to those of injured cycle and four-wheel-vehicle drivers from the Toronto trauma center, being 47.1% and 36.9%, respectively (Stoduto et al. 1991). They are considerably lower than the 54% and 70% BAC + rates for fatally injured Canadian automobile and motorcycle drivers, respectively (Mayhew et al. 1987). The preinjury alcohol use rates in the current study are comparable for automobile and motorcycle drivers involved in fatal crashes in the United States in 1991; being, 30.6% and 51.0%, respectively (NHTSA 1993).

In a study of fatally injured drivers, Buhlman, Simpson, and Warren (1979) also found higher BACs among automobile drivers than among cyclists. They could not find support for the contention that the younger cyclists were more easily impaired at lower BACs. In regard to our younger group of injured cyclists, we agree with Buhlman and colleagues (1979) that a discussion of the cyclists' lower BACs is outside the scope of this report and that the matter "requires careful consideration and further research."

As noted, the study design precluded linking THC test results with other results, including BACs. Marijuana and other drugs are frequently used in combination with alcohol (Soderstrom et al. 1988; Cimbura et al. 1990; Lindenbaum et al. 1989; Mason and McBay 1984; Rivara et al. 1989; Terhune and Fell 1981; Williams et al. 1985). More than 80% of the THC + fatally injured Canadian automobile and motorcycle drivers had used alcohol prior to crashing (Mayhew et al. 1987).

Cocaine

The cocaine use rate among the cycle drivers was higher than that among the automobile drivers, being 8.0% and 5.0% (p < .08), respectively. These results are considerably higher than the 2% positive rate noted by Terhune and Fell (1981) (again, note 29% test refusal rate). They are more consistent with those from the Seattle trauma center (Rivara et al. 1989). Among 67 injured cyclists and 143 other injured vehicle occupants, the cocaine use rates were approximately 10% and 8%, respectively.

Phencyclidine (PCP)

There are few data concerning PCP use among trauma center patients. As noted, 1.5% and 3.1% of the injured automobile and motorcycle drivers, respectively, tested positive for PCP. The PCP+ test rates in the current study were also considerably lower than Sloan and associates' (1989) 10% for 623 trauma center patients.

Perspectives

Information about psychoactive-substance use among injured drivers treated in trauma centers is lacking, particularly for drugs other than alcohol. A national survey of such centers indicated that admission BAC testing was routine at 62% and other drug testing was practiced routinely at 38% (Soderstrom, Dailey, and Kerns 1994).

This report examines alcohol and other drug use among crash victims admitted to a mid-Atlantic regional trauma center. Results from other areas may vary significantly. Additional information is needed to define the scope of the substance use problems, to monitor trends, and to implement both inpatient and outpatient countermeasure programs, including treatment for addiction.

SUMMARY

This study indicates that preinjury marijuana use among automobile drivers admitted to a mid-Atlantic regional trauma center has decreased markedly. The same has not occurred among cyclists. In addition, alcohol, cocaine, and PCP use was higher for the cyclists.

Acknowledgements—The authors express their gratitude to the Office of Traffic Safety, Traffic Safety Division, Maryland State Highway Administration, and to the Central Accident Records of the Maryland State Police. The Maryland Trauma Registry data were obtained through the efforts of the members of the Maryland Trauma Network and staff at the Maryland Institute for Emergency Medical Services Systems. Specific thanks is extended to all trauma centers' coordinators and to the staff of MIEMSS Operations Research and Systems Analysis.

REFERENCES

- Buhlman, M. A.; Simpson, H. R.; Warren, R. A. Alcohol and other factors in fatal motorcycle collisions: A preliminary analysis. Can. Soc. Forensic Sci. J. 12:65-74; 1979.
- Champion, H. R.; Copes, W. S.; Sacco, W. J.; Lawnick, M. M.; Keast, S. L.; Bain, L. W.; Flanagan, M. E.; Frey, C. F. The major trauma outcome study: Establishing national norms for trauma care. J. Trauma 30:1356–1365; 1990.
- Cimbura, G.; Lucas, D. M.; Bennett, R. C.; Donelson, A. C. Incidence and toxicological aspects of cannabis and ethanol detected in 1394 fatally injured drivers and pedestrians in Ontario (1982–1984). J. Forensic Sci. 35:1035–1041; 1990.
- Clark, R. F.; Harchelroad, F. Toxicology screening of the trauma patient: A changing profile. Ann. Emerg. Med. 20:151–153; 1991.
- Ellis, G. M.; Mann, M. A.; Judson, B. A.; Schramm, N. T.; Tashchian, A. Excretion pattern of cannabinoid

metabolites after the last use in a group of chronic users. Clin. Pharmacol. Ther. 38:572-578; 1985.

- Heustis, M. A., Henningfield, J. E.; Cone, E. J. Blood cannabinoids: I. Absorption of THC and formation of 11-OH-THC and THCCOOH during and after smoking marijuana. J. Anal. Toxicol. 16:276–282; 1992.
- Kirby, J. M.; Maull, K. I.; Fain, W. Comparability of alcohol and drug use in injured drivers. South. Med. J. 85:800-802; 1992.
- Lindenbaum, G. A.; Carroll, S. F.; Daskal, I.; Kapusnick, R. Patterns of alcohol and drug abuse in an urban trauma center: The increasing role of cocaine abuse. J. Trauma 29:1654–1658; 1989.
- Mason, A. P.; McBay, A. J. Ethanol, marijuana, and other drug use in 600 drivers killed in single-vehicle crashes in North Carolina, 1978–1981. J. Forensic Sci. 29:987–1026; 1984.
- Mayhew, D. R.; Donelson, A. C.; Simpson, H. R. Alcohol and cannabis among fatally injured motorcyclists. In: Noordzij, P. C.; Roszbach, R., editors. Alcohol, drugs, and traffic safety-T-86. Amsterdam, The Netherlands: Elsevier Science Pub.; 1987:267-270.
- Moeller, M. R.; Doerr, G.; Warth, S. Simultaneous quantitation of delta-9-tetrahydrocannabinol (THC) and 11nor-9-carboxy-delta-9-tetrahydrocannabinol (THC-COOH) in serum by GC/MS using deuterated internal standards and its application to a smoking study and forensic cases. J. Forensic Sci. 37:969–983; 1992.
- NHTSA (National Highway Traffic Safety Administration) FARS 91—Fatal accident reporting system 1991: A review of information on fatal traffic crashes in the United States. DOT HS 807 954. Washington, DC: U.S. Department of Transportation; March 1993.
- National Institute on Drug Abuse: National Household Survey of Drug Abuse: Main Findings 1985. DHHS publication no. (ADM) 88-1586. Rockville, MD: NIDA, U.S. Department of Health and Human Services; 1988.
- National Institute on Drug Abuse: National Household Survey of Drug Abuse: Population Estimates 1988.
 DHHS publication no. (ADM) 89-1636. Rockville, MD: NIDA, U.S. Department of Health and Human Services; 1989.
- National Institute on Drug Abuse: National Household Survey of Drug Abuse: Population Estimates 1991. DHHS publication no. (ADM) 92-1887. Rockville, MD: NIDA, U.S. Department of Health and Human Services; 1991.

- Rivara, F. P.; Mueller, B. A.; Fligner, C. L.; Luna, G.; Raisys, V. A.; Copass, M.; Reay, D. T. Drug use in trauma victims. J. Trauma 29:462–470; 1989.
- SAMIS (Substance Abuse Management Information System). TAB 8: Maryland indicators: public health information. Center for Substance Abuse Research's Compendium of Drug Abuse Indicators. College Park, MD: Maryland Alcohol and Drug Abuse Administration; November, 1992.
- Sloan, E. P.; Zalenski, R. J.; Smith, R. F.; Sheaff, C. M.; Chen, E. H.; Keys, N. I.; Crescenzo, M.; Barrett, J. A.; Berman, E. Toxicology screening in urban trauma patients: Drug prevalence and its relationship to trauma severity and management. J. Trauma 29:1647-1653; 1989.
- Soderstrom, C. A.; Dailey, J. T.; Kerns, T. J. Alcohol and other drugs: An assessment of testing and clinical practices in U.S. trauma centers. J. Trauma 36:68–73; 1994.
- Soderstrom, C. A.; Dischinger, P. C.; Ho, S. M.; Soderstrom, M. T. Alcohol use, driving records, and crash culpability among injured motorcycle drivers. Accid. Anal. Prev. 25:711-716; 1993.
- Soderstrom, C. A.; Trifillis, A. L.; Shankar, B. S.; Clark, W. E.; Cowley R. A. Marijuana and alcohol use among 1023 trauma patients: A prospective study. Arch. Surg. 123:733-737; 1988.
- Stoduto, G.; Vingilis, E.; Kapur, B. M.; Sheu, W. J.; McLellan, B. A.; Liban, C. Alcohol and drugs in motor vehicle collision admissions to a regional trauma unit: Demographics, injury and crash characteristics. Proceedings of the 35th Annual Meeting, Association for the Advancement of Automotive Medicine, Toronto, Canada, October 7–9, 1991; 235–247.
- Terhune, K. W.; Fell, J. C. The role of alcohol, marijuana, and other drugs in the accidents of drivers (NHTSA technical report DOT-HS-806-181). Proceedings of the 25th Annual Meeting, American Association of Automotive Medicine, San Francisco, CA, October 1-3, 1981.
- Williams, A. F.; Peat, M. A.; Crouch, D. J.; Wells, J. K.; Finkle, B. S. Drugs in fatally injured young male drivers. Public Health Rep. 100:19–25; 1985.
- Yeager, E. P.; Goebelsmann, U.; Soares, J. R.; Grant, J. D.; Gross, S. J. Delta-9-tetrahydrocannabinol by GLC-MS validated radioimmunoassay of hemolyzed blood or serum. J. Anal. Toxicol. 5:81-84; 1981.